EXHIBIT 5

UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

ANNE DE LACOUR, ANDREA WRIGHT, and LOREE MORAN individually and on behalf of all others similarly situated, Plaintiffs, v. COLGATE-PALMOLIVE CO., and TOM'S OF MAINE INC. Defendants.	Civil Action No. 1:16-CV-08364-KW

EXPERT REPORT OF ZHAOHUI SUNNY ZHOU

Dated: July 22, 2022

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I, Zhaohui Sunny Zhou, make this declaration based on personal knowledge and if called to testify, I could and would competently testify to the matters contained herein.

I. SUMMARY OF QUALIFICATIONS

1. I hold a Bachelor of Science degree in Organic Chemistry from Peking University, Beijing, China, and a Ph.D. in Bioorganic Chemistry from The Scripps Research Institute in La Jolla, California.

2. Following my doctorate program, I worked as a research fellow at the University of Michigan in Ann Arbor, Michigan. My postdoctoral work at the University of Michigan focused on naturally occurring vitamins (e.g., folic acid, vitamin B9) and amino acids (e.g., methionine), including their biochemical mechanisms, transformations and impact on human health and diseases. The research in our laboratory (Professor Rowena G. Matthews) set the scientific foundation for fortification of foods (e.g., flours, breads and cereals) with folic acid, which continues to prevent neural tube birth defect.

3. I am currently employed by Northeastern University as a Professor in the Department of Chemistry and Chemical Biology, Faculty Fellow of the Barnett Institute of Chemical and Biological Analysis, and Affiliated Faculty of Bioengineering and Biology.

4. I have expertise in the areas of chemistry, biochemistry and chemical biology, and have been researching and teaching various aspects of chemistry related to natural products and derivatives since 1990, including their isolation, synthesis, analysis, characterization, and biological function.

5. In 1990, as a staff scientist at the Academy of Traditional Chinese Medicine and Materia Medica (Changchun, China), I isolated, derivatized and characterized several natural products from medical plants and other traditional Chinese medicine.

6. I have served as a reviewer for federal, non-profit and private funding agencies, such as the National Institutes of Health (NIH), including the bio-organic and natural products chemistry (BNP) study section.

7. I have received over one million dollars in grants from the National Institute of Health (NIH), the National Institute of Allergy and Infectious Diseases (NIAID) to investigate bacterial signaling (specifically, quorum sensing) and infection, which is pertinent to oral hygiene and health (e.g., biofilm and plaque). This program included the investigation of the chemistry and biology of halogenated furanones (a family of natural products) as potential anti-bacterial agents. I have published in scientific journals covering natural products, such as *Natural Product Communications* (see my curriculum vitae for the full list).

8. I have served as a Visiting Professor of Dermatology and Visiting Scientist at the Wellman Center for Photomedicine, Massachusetts General Hospital, and Harvard Medical School in Boston, Massachusetts. As a result of this work, I am specifically familiar with the chemistry of personal care products.

9. My curriculum vitae, a true and correct copy of which is attached hereto as Appendix A, outlines my background, education, research, academic distinctions, and scientific publications.

10. Within the previous four years, I have been retained as an expert in numerous litigations, including two litigations where my work involved the analysis of "natural" products. Attached hereto as Appendix B is a list of litigations in which I have provided expert testimony.

II. SCOPE OF ASSIGNMENT AND MATERIALS REVIEWED

11. I have been retained as an expert witness by Plaintiffs in the matter of *de Lacour et al., v. Colgate-Palmolive Co. and Tom's of Maine Inc.*, Case No. 1:16-CV-08364-KW.

12. I have been retained by Plaintiffs in this action to objectively evaluate the scientific merit of claims made by Defendants Tom's of Maine, Inc. and Colgate-Palmolive Co. with respect to the "natural" nature of Tom's of Maine brand toothpaste and deodorant products and certain ingredients contained therein.

13. Specifically, I have been asked to evaluate the following ingredients contained in certain Tom's of Maine toothpaste and/or deodorant products (the "Ingredients"): sodium lauryl sulfate, propylene glycol, xanthan gum, sorbitol, xylitol, glycerin, and ascorbic acid.

14. A full list of materials I have reviewed in preparation for this report is attached hereto as Appendix C.

15. I have been retained and am being compensated by Plaintiffs' counsel at my hourly rate for my work done in this matter. My hourly rate in this matter is $500 per hour. My compensation is not contingent upon the outcome in this matter.

III. THE MEANING OF "NATURAL"

16. The term "natural" is defined in several dictionaries.

17. Oxford Learner's Dictionaries has the following definitions of "natural":[1]

a. "existing in nature; not made or caused by humans"

b. "(especially of food) having little or no processing"

c. "normal; as you would expect"

18. Merriam-Webster has the following definitions of "natural":[2]

a. "existing in or produced by nature: not artificial"

b. "growing without human care, also: not cultivated"

c. "being or acting as expected"

19. Various governmental and regulatory agencies have also issued guidance regarding use of term "natural."

20. The United States Food and Drug Administration (FDA) has posted the following policy: "Although the FDA has not engaged in rulemaking to establish a formal definition for the term "natural," we do have a longstanding policy concerning the use of "natural" in human food labeling. The FDA has considered the term **"natural" to mean that nothing artificial or**

[1] https://www.oxfordlearnersdictionaries.com/us/definition/english/natural_1 (last visited July 20, 2022).

[2] https://www.merriam-webster.com/dictionary/natural (last visited on July 20, 2022).

synthetic (including all color additives regardless of source) has been included in, or has been added to, a food that would not normally be expected to be in that food."[3]

21. U.S. Department of Agriculture (USDA) has the following definition of "natural": "A product labeled "natural" is a product containing no artificial ingredient or added color and is only minimally processed. **Minimal processing** means that the product was processed in a manner that does not fundamentally alter the product. The label must include a statement explaining the meaning of the term natural (such as "no artificial ingredients; minimally processed")."[4]

22. The scientific community has also defined "natural products." One such definition from a leading peer-reviewed journal *Nature* is as follows: "Natural products are small molecules produced naturally by any organism including primary and secondary metabolites."[5]

23. These definitions may emphasize different aspects, but are consistent among themselves, such as "nothing artificial or synthetic" and "only minimally processed."

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[3] https://www.fda.gov/food/food-labeling-nutrition/use-term-natural-food-labeling (content current as of October 22, 2018)

[4] https://ask.usda.gov/s/article/What-does-natural-meat-and-poultry-mean (Dated July 17, 2019). [Underline and bold fonts are added for emphasis]

[5] https://www.nature.com/subjects/natural-products#:~:text=Natural%20products%20are%20small%20molecules,complex%20structures%2C%20such%20as%20Taxol (Last viewed July 20, 2022).

IV. ANALYSIS AND OPINION OF INGREDIENTS IN TOM'S OF MAINE PRODUCTS

24. The following chart details the ingredients I have been asked to evaluate, along with a description of the manufacturing process used by Defendants for each ingredient:

Ingredient	Exists in Nature	Isolated from Nature	Minimally Processed	Manufacturing Process
Sodium lauryl sulfate (SLS)	no	no	no	Multi-step chemical synthesis: e.g., esterification, hydrogenation, and sulphonation (sulfonation).
Propylene glycol	no	no	no	Multi-step chemical synthesis: e.g., hydrogenolysis, and a mixture of stereoisomers.
Xanhtan gum	no	no	no	Fermentation with modified non-natural bacteria and man-made multi-step processes.
Sorbitol	yes	no	no	Multi-step chemical synthesis: e.g., hydrogenation (heavy metal, Raney nickel).
Xylitol	yes	no	no	Multi-step chemical synthesis: e.g., hydrogenation. Starting material, xylan, extracted from birch or hardwood pulp, or corn.
Glycerin	yes	no	no	Multi-step chemical synthesis: e.g., hydrolysis, distillation, and carbon bleaching.
Ascorbic acid	yes	no	no	Defendants state "derived from citrus fruits."

A. Sodium Lauryl Sulfate

25. Sodium lauryl sulfate (SLS), a non-natural and man-made chemical, is the sodium (Na) salt of 12-hydrocarbon sulfate (SO_4). Its structure is depicted below:

26. Its long hydrocarbon (fatty) chain is hydrophobic (i.e., water repelling), and its sulfate group is polar, highly charged, and hydrophilic (i.e., attracted to water). The combination of a hydrophilic moiety (headgroup) and a hydrophobic moiety makes SLS amphiphilic, thereby rendering it an anionic surfactant, detergent, and denaturant.

27. SLS is also referred as sodium dodecyl sulfate (SDS), widely used in scientific research as a strong surfactant, detergent, and denaturant. For instance, SDS is a commonly used a component to break cell membrane (lysis) with lipids (oil layers) before extraction of RNA and DNA from inside the cells. As highlighted by Thibeault (Analytical Biochemistry, 2019, 571, 21-24), "Sodium dodecyl sulfate (SDS) is a detergent used as a strong denaturant of proteins in gel electrophoresis." For such applications (e.g., SDS-PAGE, polyacrylamide gel electrophoresis), SDS disrupts non-covalent interactions in proteins, and hence denatures the protein; in other words, causes the proteins to lose their native structures and functions. Furthermore, "Because of its high denaturing strength, **relatively few proteins are resistant to SDS**." [Underline and bold fonts are added for emphasis.] Due to its intrinsic harsh chemical and biochemical properties, SLS/SDS should be handled with great care in the laboratory, as it causes skin irritation, causes serious eye damage, and may cause respiratory irritation. For example, the safety data sheet from Sigma Aldrich (https://www.sigmaaldrich.com/US/en/product/sial/l4509, revision date December 27, 2021) specifically calls for careful handling of this reagent, stating that those handling it must

"wear protective gloves/eye protection/face protection." Moreover, SLS/SDS damages the environment, and is "toxic to aquatic life" with long lasting effects.[6]

28. Similarly, due to the intrinsic harsh chemical and biochemical properties of SLS/SDS, they pose significant concerns and risks in consumer and health products. As the Defendants' own suppliers clearly stated in their patent applications (e.g., U.S. Patent 9,668,956, granted June 6, 2017; filed May 21, 2014), "Alkylsulfates and alkyl ether sulfates are known for being harsh on both skin and hair. In fact SLS is taken as a standard irritant for irritancy measurement." Furthermore, "skin's moisture regulation mechanism is seriously affected due to adverse action of harsh surfactants on the proteins and lipids of upper layers of stratum corneum." As such, the Defendants' own SLS supplier, Galaxy Surfactants, has been actively developing patented new products to replace SLS and other products "without sulfates." However, despite these warning and concerns of its own SLS supplier, Defendants use this non-natural ingredient, which may be harmful to consumers.

29. Defendants have provided a general description on how SLS is made.[7] Defendants state that "The SLS Tom's of Maine uses is entirely derived from the vegetable sources of coconut and/or palm kernel oil. The oils can be split into glycerin and the component fatty acids, one of which is lauric acid. The lauric acid is isolated and then hydrogenated to form the lauryl alcohol. Alternately, the whole oil can be esterified and then hydrogenated to form the fatty alcohols of which lauryl alcohol would be isolated by fractionation. The lauryl alcohol is then combined with sulfur which then forms the salt, sodium lauryl sulfate."

30. Defendants provided a copy of a PowerPoint presentation from Galaxy Surfactants, Defendants' SLS supplier, which provides a brief summary of the manufacturing process of SLS.[8] According to Defendants' supplier, multiple steps are involved in the synthesis, purification and processing of SLS. After the initial separation of the raw materials to obtain the fatty acids, a

[6] https://www.sigmaaldrich.com/US/en/product/sial/l4509, revision date December 27, 2021

[7] Defendants' Responses to Plaintiffs' Second Set of Interrogatories, Response No. 21

[8] Galaxy SLS Manufacturing Process PowerPoint Presentation, COLGATETOMS00214921.

chemical step (esterification) affords the corresponding methyl esters as at the intermediate stage (of note, no details are provided for the esterification). Subsequently, hydrogenation of either the fatty acids or methyl esters affords the fatty alcohol. Next, the fatty alcohol and sulphur (common spelling in India, where the supplier Galaxy Surfactants is headquartered; and sulfur, common spelling in USA) are combined (sulphonation or sulfonation), presumably to yield sodium dodecyl sulfate (of note, no details are provided by Defendants). Yet still more steps (neutralization, drying, needling, and granulation) are involved to afford the final product (SLS granules). Even without the details, each and all of these manufacturing steps are non-natural and man-made chemical syntheses, often using toxic reagents and harsh conditions.

31. Esterification: Esterification, which is a chemical process that converts a carboxylic acid to the corresponding ester, is an artificial, man-made chemical synthesis that has no counterpart in nature. SLS used by Defendants would have undergone this process.

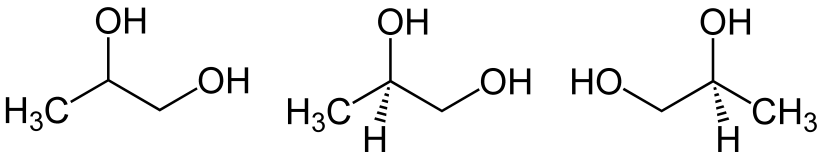
32. Hydrogenation: The hydrogenation processes utilized by Defendants' SLS supplier (Galaxy Surfactants) are artificial, man-made chemical synthesis that have no counterpart in nature. Based on the scientific literature, common reagents for hydrogenation of fatty acids and their esters to the alcohols require heavy metal catalysts (e.g., ruthenium (Ru), iridium (Ir), osmium (Os), or other precious metals) and organic solvents; and the reactions are conducted at high temperatures and high pressure. As summarized by industrial scientists (Fairweather et al; Organometallics, 2015, 34, 1, 335–339), "the hydrogenation of fatty acid methyl esters (FAMEs) to produce fatty alcohols is conducted industrially on a multimillion ton scale each year for a variety of applications. Relevant to the business at the Procter and Gamble Co. (P&G) is the subsequent use of the fatty alcohols as surfactant precursors. Our current process involves the hydrogenation of FAMEs through a heterogeneous copper chromite catalyst that operates at high temperature (250–300 °C) and H2 pressure (2000–3000 psig). Because the process under these conditions has been run continuously for almost 50 years within P&G, we are keenly aware of the high energy and capital costs associated with the process."

33. Sulphonation (or sulfonation): Defendants note that the SLS used in their products undergo sulphonating. Defendants do not provide specific details on the sulphonation step, except to describe it as follows: "The lauryl alcohol is then combined with sulfur which then forms the salt, sodium lauryl sulfate."[9] Nonetheless, the sulfonation chemical reactions are non-natural and employ harsh conditions.

34. Each and all of these manufacturing steps for SLS are non-natural and man-made chemical syntheses, often using toxic reagents and harsh conditions. Given that SLS is a non-natural man-made chemical that undergoes all of the above-described manufacturing processes, it cannot be accurately described as "natural."

B. <u>Propylene Glycol</u>

35. Propylene Glycol is a non-natural and man-made chemical also called propane-1,2-diol or alpha-propylene glycol. Its structure is depicted below (HO- or -OH denotes a hydroxyl group or alcohol):



36. Propylene glycol can exist in two stereoisomers as the four different functional groups (i.e., -H, -OH, -CH_3 and -CH2OH) that are attached to the center carbon (chiral center) can have different arrangements in space.

37. Defendants state that in manufacturing propylene glycol "our suppliers use a catalytic process called hydrogenolysis to covert glycerin into propylene glycol. A reaction between glycerin (obtained from vegetable oils) and hydrogen takes place at high temperature and pressures."[10]

[9] Defendants' Response to Interrogatory No. 21 from Defendants' Responses to Plaintiffs' Second Set of Interrogatories.
[10] Defendants' Response to Interrogatory No. 20 from Defendants' Responses to Plaintiffs' Second Set of Interrogatories.

38. Hydrogenolysis is a chemical process in which a carbon-carbon (C-C) or carbon-heteroatom (any atom other than carbon or hydrogen) single bond is cleaved or undergoes "lysis" by hydrogen gas (H_2). The term itself was coined by American chemist Carleton Ellis. Catalysts (e.g., heavy metals) and harsh conditions (e.g., high temperature, 180 to 250 C; and high pressure, 1,000-2,000 psi) are required for hydrogenolysis.

39. In fact, Defendants' supplier of propylene glycol, Archer Daniels Midland Company (ADM), developed and patented a manufacturing process using hydrogenolysis of glycerol to produce propylene glycol (see U.S. Patent 8,153,847, granted on April 10, 2012; filed on October 23, 2007; Inventor Paul Bloom). The U.S. Patent states that "The processes involved in the hydrogenolysis of glycerol may be carried out by any of the known routes. These include heterogeneous metal catalysts … The processes also include homogenous catalysts …". Moreover, specific examples of catalysts are given, including nickel, SiO_2 and Al_2O_3 (see Table 4). These catalysts are not only non-natural, but also toxic to humans. Moreover, the fact the Defendants' suppliers have invented and patented these manufacturing processes further proves that these processes are non-natural and man-made, according to the requirements of U.S. and international patent laws (e.g., all inventions have to be new and non-obvious).

40. As aforementioned, propylene glycol can exist as a pair of two stereoisomers, like baseball gloves (one fits the left hand; and other, the right hand). The industrial chemical hydrogenolysis manufacturing processes afford a mixture of these two stereoisomers. In contrast, a natural product that is produced naturally exist in a single stereoisomer. Stereoisomers are different chemical entities and exhibit different physio-chemical properties and reactivities, and moreover, biological activities. For instance, one stereoisomer may be biological activity while the other inactive. In several cases, one stereoisomer has been found toxic to humans, while the others are not. This is analogous to the baseball gloves: the right-hand glove will not fit into a left hand, or at least will not work properly (drop the ball).

41. Thalidomide, unfortunately, epitomizes the unforeseen toxicity of stereoisomers. Thalidomide became widely available in late 1950s and early 1960s to treat morning sickness

during pregnancy. However, it was found to cause disabilities in the babies born to mothers who took the drug. The total number of infants affected is estimated around 10,000, and 40% died around the time of birth. As a result, the drug was quickly banned and withdrawn from the market. Later scientific research established that one of the isomers was the culprit for the toxicity that caused the disabilities and death in the babies.

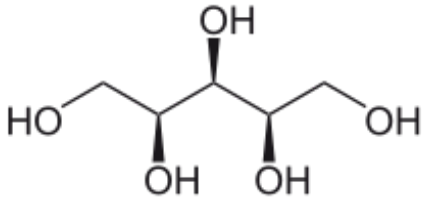
42. These principles are summarized in a review by Silas W. Smith in a peer-reviewed scientific journal (Toxicological Sciences, 2009, 110, 4-30) entitled "Chiral Toxicology: It's the Same Thing…Only Different." Its abstract begins with "chiral substances possess a unique architecture such that, despite sharing identical molecular formulas, atom-to-atom linkages, and bonding distances, they cannot be superimposed. Thus, in the environment of living systems, where specific structure-activity relationships may be required for effect (e.g., enzymes, receptors, transporters, and DNA), the physiochemical and biochemical properties of racemic mixtures and individual stereoisomers can differ significantly. In drug development, enantiomeric selection to maximize clinical effects or mitigate drug toxicity has yielded both success and failure." Altogether, because different stereoisomers may exhibit drastically different biological activities, especially unforeseen toxicity, almost all small molecules drugs are now synthesized in a single stereoisomer.

43. Impurities are always safety concerns, particularly for non-natural chemical manufacturing processes that use highly toxic reagents (e.g., nickel, aluminum, and/or other heavy metal ions for catalytic hydrogenolysis). For example, in U.S. Patent 8,153,847, the Defendants' supplier ADM states, "the impurity of the polyol product mixture (derivatives) presents a problem for sale and use of the product." Even though the final products undergo extensive purification, impurities always remain. Information from Defendants' three chemical manufacturers and suppliers, ADM, Down Chemical and Lyondell Chemical support this fact. For instance, the Safety Data Sheet from ADM (original preparation date: 01-Mar-2010; revision date: 19-Feb-2018; revision number: 2) lists the levels of 1,2-propylene glycol at 99.5% and water at 0.2%, respectively; that still leaves 0.3% impurities that are not accounted for.

44. In sum, propylene glycol is a non-natural chemical and is produced by non-natural man-made chemical manufacturing processes that use highly toxic materials under harsh conditions, and moreover, produced as a mixture of two stereoisomers. Given that propylene glycol is a non-natural man-made chemical that undergoes all of the above-described manufacturing processes, it cannot be accurately described as "natural."

C. Xylitol

45. Xylitol is a sugar alcohol or polyalcohol with five carbon atoms and five hydroxyl (OH) groups. Its structure is depicted below:



46. The xylitol in Defendants' products is not isolated from nature, but is produced by large scale chemical manufacturing processes, as Defendants stated, "The xylitol used in Tom's of Maine products is produced by hydrolyzing xylan, which is extracted from birch or other hardwood pulp, or corn, to produce xylose. This material is then converted to xylitol through catalytic hydrogenation."[11]

47. The non-natural hydrogenation step is confirmed by Danisco, Defendants' supplier of xylitol. Xylitol Process Sheet dated on August 15, 2016. As discussed in great details in other sections in this report, hydrogenation is non-natural man-made chemical process, which requires heavy metals as catalysts (e.g., nickel) and harsh conditions (e.g., high temperature and pressure). Again, since many reagents are toxic and non-natural, they have to be removed with additional multiple-step processes, which is confirmed in the Xylitol Process Sheet by Danisco, the supplier used by Defendants.

[11] Defendants' Response to Interrogatory No. 23 from Defendants' Responses to Plaintiffs' Second Set of Interrogatories.

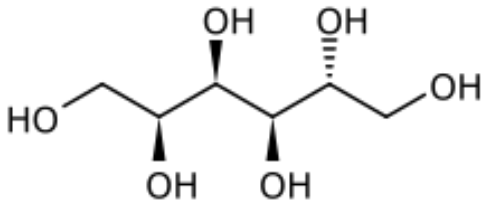
48. U.S. Patent 8,816,068 entitled "Hydrogenation Process for the Production of Sugar Alcohol" was granted on August 26, 2014 with the initial file date of April 27, 2006. The process was invented by Jyrki Kuusisto and others.[12] The patent was initially owned by Danisco A/S, Denmark (date: 2008-12-11) and later transferred to other companies, such as Dupont Nutrition Biosciences APS, Denmark. As discussed in great detail in other sections in this report, a patented process—by legal definition—is non-natural and man-made.

49. Moreover, the direct precursor of xylitol is xylose that is not isolated from nature but through the hydrolysis of xylan, which is in turn extracted from birch or other hardwood pulp, or corn as stated by the Defendants; in other words, with heavy processing as admitted by the Defendants, "there is some processing involved."

50. In sum, xylitol is produced from starting materials that are heavily processed and using non-natural, man-made chemical manufacturing processes that require toxic heavy metal catalysts (e.g., nickel) and harsh conditions (e.g., high temperature and pressure). Xylitol cannot be accurately described as "natural."

D. <u>Sorbitol</u>

51. Sorbitol is a sugar alcohol or polyalcohol with six carbon atoms and six hydroxyl (OH) groups. Its structure is depicted below:



52. Sorbitol in the Defendants' products is not isolated from nature, but rather produced by large scale chemical manufacturing processes, as the Defendants stated, "to produce Tom's sorbitol, corn goes through a wet-milling process to make the basic products of starch, gluten, fiber, and corn oil. The starch component is exposed to enzymes and broken

[12] https://patents.google.com/patent/US8816068B2/en)

down into simple sugars to produce glucose (dextrose). Then, the addition of hydrogen over metal catalyst converts glucose into sorbitol. Acids and bases are utilized throughout the process along with carbon and/or ion exchange treatment in the purification step."

53. Hydrogenation is the scientific term for "addition of hydrogen over metal catalyst" as the Defendants noted. More details are available from Roquette (a supplier of the Defendants). Roquette's Sorbitol Process Sheet (Neosorb, Liquid Sorbitol; dated October 2014) discloses that Raney nickel is used for hydrogenation. As discussed in other sections of this report, heavy metals, such as Raney nickel, are toxic. Indeed, Roquette recognizes the toxicity itself with clear marking and warning in its Process Sheet; for example, "Raney Nickel (particles)" is labeled as "Hazard" and "Foreign Material." In other words, these materials are non-natural.

54. Furthermore, because non-natural chemicals are used for the manufacture, they must be removed from the final products, as they are foreign and hazardous materials (even recognized by the suppliers for the Defendants, e.g., Roquette for sorbitol, see Sorbitol Process Sheet). To remove this toxic reagent, a designated step "demineralization" is put into place in the overall manufacturing process.

55. While most of these foreign materials may be reduced below certain thresholds or detection limits, they may still be present at certain levels. In addition, it is not trivial to sufficiently remove these foreign materials, as the processes may fail from time to time (see Sorbitol Process Sheet from Roquette, a supplier for the Defendants).

56. Yet another issue in the manufacture processes is that additional non-natural steps have to be introduced to remove these non-natural (foreign) materials, as by definition, any processes that deal with non-natural materials are non-natural by definition. For instance, demineralization is required after by hydrogenation using Raney nickel. Again, because Raney nickel does not exist in nature, the additional required demineralization step is non-natural (man-made) by definition. Moreover, this demineralization step adds to already complex and complicated manufacturing processes, which is exactly the opposite of minimally processed.

57. Given that the sorbitol used in Defendants' products undergoes all of the above-described manufacturing processes, it cannot be accurately described as "natural."

E. Xanthan Gum

58. Xanthan gum is a highly heterogenous mixture of complex non-natural artificial polysaccharides (i.e., polymer of carbohydrates) that was developed in the 1960's. It derives its name from the bacteria species, *Xanthomonas campestris*, that are used for its production. The same family of bacteria species causes black rot on leafy vegetables, such as broccoli and cauliflower. Defendants' xanthan gum supplier, ADM, confirms in its Material Safety Data Sheet that xanthan gum is manufactured, stating "Xanthan Gum. Polysaccharide gum produced by the fermentation of carbohydrate with the bacterium Xanthomonas campestris."[13]

59. Almost all bacteria for industrial production are modified or engineered (i.e., non-natural or man-made) for a number of reasons; and the same for the fermentation processes (i.e., non-natural or man-made). For instance, naturally existing strains of bacteria seldom produce the target product(s) at desirable yields for commercial production, and typically prefer certain nutrients or starting materials other than the materials (feedstock) that are preferred by the commercial manufacturers.

60. Indeed, this is the case for the xanthan gum produced by Defendants' supplier ADM. ADM has patented a series manufacturing processes for xanthan gum. In U.S. Patent 3,271,267 entitled "Biochemical Synthesis of Industrial Gums" (inventors: Ralph O. Weber, et al; September 6, 1966), it disclosed, "the present invention provides a **new and improved** process for the synthesis of Xanthomonas gum." Of note, only non-natural processes (method) or composition (compound or molecule) can be patented. This is because that all patent agencies around the world, including United States Patent and Trademark Office (USPTO), require a patentable invention to be novel (new) and non-obvious (inventive, come up by the inventors). Naturally, if a process or a composition (compound or molecule) already exists in nature, it cannot be new by

[13] ADM Material Safety Data Sheet for Xanthan Gum at https://assets.adm.com/Worldwide/Australia/Novaxan-Optixan-xantham-gum-AU.pdf

definition. Conversely, if a process (method) or composition (compound or molecule) is patented, then it cannot exist in nature. These factors, again, demonstrate that the patented Raney nickel catalyst and industrial hydrogenation processes for the manufacturing of the ingredients discussed herein are non-natural, and in fact, man-made.

61. In fact, the ADM patent itself made a compelling argument that the invented processes are new and inventive, i.e., non-natural and man-made. For example, ADM's patent states, "In all cases, higher conversion of the carbohydrate to gum is obtained from the present process, in a shorter time interval, **than can be achieved by any of the known processes of the prior art**." Specifically, the ADM's process calls for antifoaming agent. "The antifoaming agent is preferably a dimethylsiloxan polymer." Such a polymer is non-natural, artificial and man-made, thus just by this, rendering the whole manufacturing processes non-natural, artificial and man-made.

62. Furthermore, the ADM's patent also claims to use non-natural materials as feedstock for the production, such as "toasted soy flour" and "finely ground, dehulled, degerminated, grain sorghum."

63. The resulting products are further foreign to any natural products. ADM's patent specifically highlights that, "while the pure gums produced by the inventive process appear to be substantially identical (qualitatively) with similar gums prepared by prior art processes, the inventive gum products possess certain **additional**, desirable characteristics." Furthermore, it states, "these desirable characteristics can only be described, conveniently, by means of the processes for making the gums." Altogether, these statements highlight again that both the processes and the products are new, i.e., non-natural, artificial and man-made.

64. Aside from the polysaccharides, the final products are likely to contain dead bacteria cells, cell debris, genetic materials (e.g., RNA and DNA), proteins and peptides, lipids and other cell metabolites. In particular, bacteria also produce other polysaccharides. Given the complexity of the xanthan gum (a highly heterogenous mixture), it is unlikely these by-products can be completely removed or reduced to negligible levels. The Material Safety

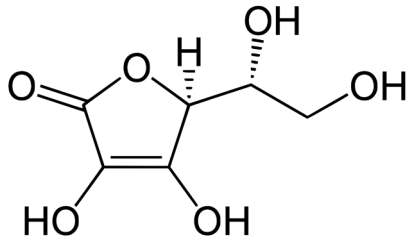
Data Sheet from ADM only states "no hazardous impurities" without any further details on the purity of the materials, let alone, the levels of any non-natural residual materials.

65. The manufacturing processes of ADM are similar to those of other manufacturers, which also have continued to invent and implement many non-natural man-made processes to improve production yields and lower the production cost, among many other commercial goals. For instance, in 1994, James J. Pollock and coworkers at Shin-Etsu Chemical patented new production bacterial strains with genetic mutation and resistance to antibiotics, e.g., rifampicin and bacitracin (U.S. Patent 5,729,961). Such strains are considered genetically modified organisms (GMOs) or genetically engineered (GE) species, therefore are non-natural, artificial and man-made.

66. Given that the xanthan gum used in Defendants' products undergoes all of the above-described manufacturing processes, it cannot be accurately described as "natural."

F. <u>Ascorbic Acid</u>

67. Ascorbic acid (also known as vitamin C) does exist in nature. Its structure is depicted below:



68. However, the ascorbic acid used in Defendants' products is not isolated from nature, and is instead manufactured with man-made processes. Defendants have not provided any details on the production of ascorbic acid other than two sentences stating that "ascorbic acid can be sourced from citrus fruits or prepared from corn glucose by a method based on the historical "Richstein process." The ascorbic acid that Tom's uses is **<u>DERIVED</u>** from citrus fruits."

69. As summarized by the Competition Commission in the United Kingdom in 2001, The manufacture of vitamin C is now carried out in two ways. These include the traditional Reichstein process and a two-stage fermentation process.[14]

70. In the first step of both the traditional Reichstein process and the newer two-stage fermentation process, sorbitol is oxidized into sorbose by fermentation. All producers use the same micro-organism for this fermentation.[15]

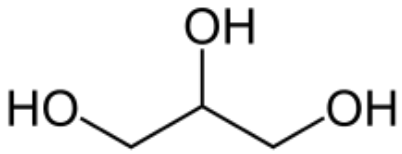
71. It is worth noting that in both commercial processes, sorbitol is used as the starting material. Sorbitol itself is made by reducing glucose at high temperature. In contrast, sorbitol is not the precursor for naturally existing biological synthesis of ascorbic acid. Moreover, the sorbitol starting material itself in turn is made by a non-natural man-made process (e.g., "at high temperature"). As such, both commercial processes are non-natural and man-made.

72. Based on the description of other processes used by the Defendants, it is clear that the ascorbic acid used in the Defendants' product is not isolated from nature, but rather manufactured from other materials by either chemical processes or fermentation or the combination of the two. Either way, the processes are non-natural and man-made.

73. Given that the ascorbic acid used in Defendants' products undergoes all of the above-described manufacturing processes, it cannot be accurately described as "natural."

G. <u>Glycerin</u>

74. Glycerin (also called glycerol) does exist in nature. Its structure is depicted below:



[14] The Production of Vitamin C: https://webarchive.nationalarchives.gov.uk/ukgwa/20120119194657/http://www.competition-commission.org.uk/rep_pub/reports/2001/fulltext/456a4.2.pdf)

[15] The Production of Vitamin C: https://webarchive.nationalarchives.gov.uk/ukgwa/20120119194657/http://www.competition-commission.org.uk/rep_pub/reports/2001/fulltext/456a4.2.pdf)

75. However, the glycerin used in Defendants' products is not isolated from nature, but rather derived by chemical processes, specifically hydrolysis. Defendants have indicated that, "Tom's also uses glycerin in oral care and personal care products that is made from hydrolysis of vegetable oil." Furthermore, additional heavy processing steps are also involved, as stated by the Defendants, "the glycerin is distilled to increase its concentration and undergoes a carbon bleaching process to obtain a highly pure ingredient." The complex multi-step manufacturing processes are confirmed by Defendants' glycerin supplier, Owensboro Grain Bio-Based Products. In Owensboro Grain's "Glycerin Process Sheet," more than five major steps and additional small steps are shown in a flow chart, including "Bleaching Filter," "Deodorize," "Yellow Glycerin Storage Tank," etc. (dated 2/18/14). As such, the manufacturing processes are non-natural and man-made.

76. Given that the glycerin used in Defendants' products undergoes the above-described manufacturing processes, it cannot be accurately described as "natural."

V. EXPLANATION OF INGREDIENT PROCESSING PROCEDURES

77. Fine chemical industrial manufacturing processes: contrary to the "natural" image Defendants want to conjure, all ingredients in the defendants' products are more fittingly described as "fine chemicals," which are produced industrially at large scale with complex non-natural man-made manufacturing processes. In fact, this practice is widely recognized, for example, reviewed by K. van Gorp in a peer-reviewed industrial journal *Catalysis Today* (1999, 52, 349-361) with the title "Catalytic Hydrogenation of Fine Chemicals: Sorbitol Production." Its abstract begins with "historically, skeletal nickel is the catalyst of choice in the production of sorbitol on industrial scale. A disadvantage of the use of skeletal nickel in the hydrogenation of glucose containing feedstocks to sorbitol, is the fact that a part of the nickel leaches." Again, it highlights a major safety and health issue due to the non-natural man-made toxic chemicals.

78. A clearer picture of the scale and complexity of the industrial process can be gleaned from Ekato, an industry leader that builds hydrogenation plants for sugar alcohol (such as xylitol and sorbitol). Its website (20 July 2022)

https://www.ekato.com/solutions/processes/hydrogenation/ shows some representative photos of such plants. For instance, the reactors are made of glass and steel containers "with filling volumes of up to 88 m^3." 1 m^3 is 1 cubic meter and equal to 1,000 liters, so the filling volume is 88,000 liters. The reactor is more than one-story tall. The processes are so complicated that they are controlled by sophisticated computers and software.

79. Hydrogenation: Patents are granted for these non-natural industrial chemical manufacturing processes and metal catalysts. For instance, Raney nickel is used for the hydrogenation of glucose to produce sorbitol (as reported by Roquette, a supplier for the defendants). This man-made material is chemically derived from a nickel-aluminum alloy, most commonly as gray solids. In 1920's, while working at Lookout Oil and Refining, American chemist Murry Raney invented the reagent which was named after him. Because of the novelty of his discovery, Raney received patents; and the Raney nickel also became a trademark of W. R. Grace and Company.

80. Only non-natural processes (method) or composition (compound or molecule) can be patented. This is because that all patent agencies around the world, including the U.S. Patent and Trademark Office (USPTO), require a patentable invention to be novel (new) and non-obvious (inventive, come up by the inventors). Naturally, if a process or a composition (compound or molecule) already exists in nature, it cannot be new by definition. Conversely, if a process (method) or composition (compound or molecule) is patented, then it cannot exist in nature. These factors, again, demonstrate that the patented Raney nickel catalyst and industrial hydrogenation processes for the manufacturing of the ingredients discussed herein are non-natural, and in fact, man-made.

81. Yet another issue in the manufacture processes is that additional non-natural steps have to be introduced to remove these non-natural (foreign) materials. As by definition, any processes that deal with non-natural materials are non-natural by definition. For instance, demineralization is required after by hydrogenation using Raney nickel. Again, because Raney nickel does not exist in nature, the additional required demineralization step is non-natural (man-

made) by definition. Moreover, this demineralization step adds to the already complex and complicated manufacturing processes, which is exactly the opposite of minimally processed.

82. The non-natural (man-made) reagents (molecules or compounds) and processes (methods) also often lead to unforeseen consequences, and in some cases, detrimental or lethal to humans. A case in point is trans fat (trans fatty acids or trans unsaturated fatty acids) that is an unintentional by-product from the hydrogenation (e.g., by Raney nickel) of vegetable and fish oils to generate saturated fatty acids (as synthetic animal fat). In the early 20th century, trans fat manufactured from vegetable oils was considered by some people more healthy than from animal sources, since trans fat naturally exits in small quantities in meat and milk. However, decades of epidemiologic analysis, basic and clinical studies have equivocally established that trans fat artificially generated from the industrial hydrogenation processes is detrimental to human health. Such trans fat is so bad that, in the 2010's, the FDA mandated the phaseout of trans fat from all food products. It is estimated that the ban of trans fat would prevent about 90,000 premature deaths annually. Altogether, this illustrates the deadly consequence of combining benign natural products (e.g., plant-based oils) with non-natural (man-made) manufacturing processes (e.g., hydrogenation with Raney nickel).

83. Fermentation is a process of producing materials by microorganisms. Traditional fermentation processes have been used by humans for thousands of years. However, for industrial manufacturing, multiple aspects of all key steps in the fermentation processes are non-natural, man-made, and artificial. First, all or at least some of the starting materials are non-natural, particularly the microorganisms that are employed (e.g., genetically modified organism (GMO) or genetically engineered (GE) species); Second, the whole manufacturing processes are non-natural; and Third, the final products may contain non-natural starting materials or by-products, such as foreign genetic materials (e.g., RNA and DNA from the genetically modified microorganisms), foreign proteins, foreign lipids and metabolites, and many other by-products.

84. Pertinent to this case, genetic engineering and genetic modification is inherently incompatible with the concept of "natural," as the processes typically introduce new or modified genes and/or regulatory elements to markedly increase the flux of one particular metabolic pathways—all of which are non-natural and man-made. And precisely because of this, many GMOs and/or processes can be patented due to their novelty (newness) and non-obviousness.

85. Even for naturally existing molecules, over production has been shown to lead to marked health issues, and in some cases, death of people (see the case of tryptophan detailed below). Without going into the scientific details, the perturbation of the natural balance often leads to the production of toxic by-products.

86. A cautionary tale and sad story was the death caused by tryptophan supplement in 1980s. Tryptophan exists in nature, and in fact, is an essential amino acid for humans. As such, supplement of tryptophan was thought to bring health benefits. In the 1980s, Showa Denko used genetically modified bacteria that could produce tryptophan at higher level than normal. However, this fermentation process of tryptophan led to unforeseen impurities that were generated directly from elevated imbalanced levels of tryptophan (see Toxicology Letters, 2018, 294, 193-204; by Klaus Klarskov, et al; entitled "Peak AAA Fatty Acid Homolog Contaminants Present in the Dietary Supplement L-Tryptophan Associated with the Onset of Eosinophilia-myalgia Syndrome"). These manufacturing processes of a "natural product" led to an outbreak of eosinophilia-myalgia syndrome (EMS) and numerous death (see JAMA, 1990, 264, 213-217, by Laurence Slutsker et al; entitled "Eosinophilia-Myalgia Syndrome Associated With Exposure to Tryptophan From a Single Manufacturer").

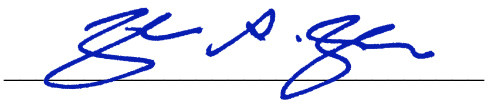
VI. CONCLUSIONS AND OPINION

87. Based on all of the scientific evidence available to me, and for the reasons set forth in this report, I conclude that the Tom's of Maine toothpaste and deodorant products at issue contain ingredients that cannot be accurately described as "natural."

88. I conclude that the Ingredients at issue are inherently incompatible with the term "natural," both in the scientific meaning of the word, as well as layperson understanding of this term.

89. The Tom's of Maine toothpaste and deodorant products at issue in this litigation cannot be accurately or fairly represented or labeled as "natural" because they contain ingredients that are heavily processed using non-natural and man-made industrial processes.

I declare under penalty of perjury that the foregoing is true and correct, and that this declaration was executed on July 22, 2022 at Wellesley, Massachusetts.



DR. ZHAOHUI SUNNY ZHOU, PH.D.